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Observations on Growth and Gametogenesis of the Atlantic Papermussel, *Amygdalum papyrium* (Conrad, 1846), from Coastal Georgia

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Abstract. The Atlantic papermussel, *Amygdalum papyrium* (Conrad, 1846), appears to be short lived (< 1 year), reaches sexual maturity at an early age, has a prolonged spawning period, and appears to be a semelparous species. Mussels were observed to recruit into areas of the Satilla River in summer 1999. By October most mussels were in the spawning stage, with this stage dominating until February 2000 when 83% of mussels were spent. All mussels were dead by March 2001. *Amygdalum papyrium* is dioecious and females dominated (4.41 females : 1.00 male) the population.

INTRODUCTION

Amygdalum papyrium (Conrad, 1846) is a small marine bivalve (< 32 mm in shell length) of the family Mytilidae that occurs from Maryland to Texas (Abbott, 1974). Members of the genus *Amygdalum* Megerle von Mühlfeld, 1811, are nest builders (Morton, 1977; Oliver, 2001), and *A. papyrium* has been described as building nests in the Chesapeake Bay (Castagna & Chanley, 1973). This species is generally found attached to submerged seagrasses (Allen, 1955) but also occurs in the intertidal zone in the Chesapeake Bay (Castagna & Chanley, 1973). *Amygdalum papyrium* is uncommon in Georgia presumably due to the absence of subtidal seagrass beds. Other than a study on larval morphology (Fuller & Lutz, 1989), little is known of its biology.

During the summer of 1999, a massive set of *A. papyrium* occurred on crab pot floats, dock floats, and dock pilings in the Satilla River, Georgia. Since these mussels appeared inland and in traditionally brackish water areas, there was concern by many that degrading water quality in the river may have triggered this recruitment. Mussels were gathered by Mr. James Holland of the Altamaha-River-Keepers Organization on 8 October 1999, and brought to the Shellfish Laboratory for identification. With the large number of mussels provided by Mr. Holland, we took the opportunity to study the growth and reproductive cycle of this mussel.

MATERIALS AND METHODS

Once the species was identified, 100 specimens were randomly selected from a crab pot float, measured for shell length (longest possible measurement, i.e., anterior-posterior) with vernier calipers, and a gonadal sample (ca. 1 cm^3 from gut) was removed from each specimen and fixed in Davidson's solution. The remaining mussels were removed from the crab pot float and placed into a 3 mm mesh pearl net and suspended from a floating dock in the Skidaway River. Each month, 50 mussels were randomly selected, measured for shell length, and a gonadal sample was obtained. After 2 day storage in Davidson's solution under refrigeration, gonadal samples were washed in 50% ETOH and preserved in 70% ETOH. All gonadal tissues were processed according to standard histological procedures for molluscan tissue (Howard & Smith, 1983). Prepared gonadal slides were examined with a Zeiss Standard 20 microscope (20×), sexed, and assigned to a developmental stage as described by Walker & Heffernan (1994) and Spruck et al. (1994). Scores from 0 to 5 were employed for Early Active (EA = 3), Late Active (LA = 4), Ripe (R = 5), Partially Spawned (PS = 2), Spent (SP = 1), and Inactive (IA = 0) stages. Monthly gonadal index (G.I.) values were determined for each sex by averaging the number of specimens ascribed to each category score. Sex ratios were tested against a 1:1 ratio with chi-square statistics (Elliott, 1977).

Mussels from a second crab pot float were sorted into two size classes (i.e., 10 to 20 mm and 20 to 30 mm in shell length) in November 1999. One hundred mussels of each size group were placed into 3 mm mesh pearl nets and suspended from a floating dock on the Skidaway River. Each month all live mussels were measured for shell length, and mortality was recorded. The pearl nets were cleaned of fouling organisms; the mussels were subsequently returned to the nets and re-suspended in the Skidaway River.

Voucher specimens from this study are currently housed in the shellfish collection at the Shellfish Research Laboratory on Skidaway Island, which will be turned over to the University of Georgia Museum of Natural History in Athens, Georgia in the near future.

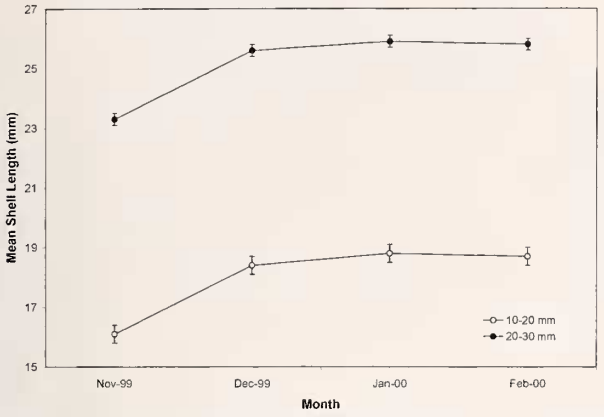

Figure 1. The mean monthly shell length ± SE of *Amygdalum papyrium* from two size classes (10–20 mm, 20–30 mm) grown in pearl nets suspended from a dock in the Skidaway River from November 1999 (n = 100 for each size group) to February 2000 (10–20 mm: n = 89; 20–30 mm: n = 94).

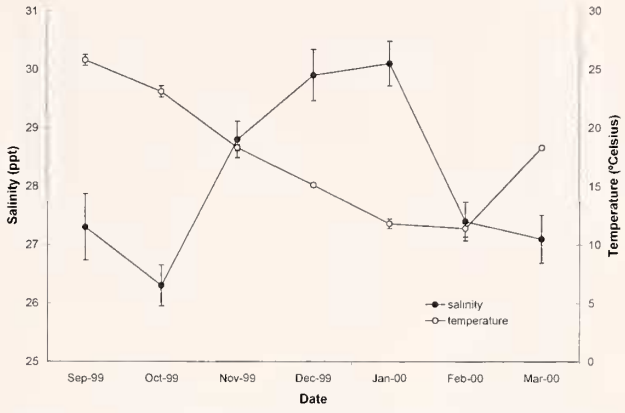

Figure 2. The monthly mean water temperature and salinity values ± SE for the Skidaway River between September 1999 and March 2000.

RESULTS

Low growth rates were observed for mussels between November 1999 and February 2000, prior to the total mortality of the cohort in March (Figure 1). Mussels used for the histological analysis of gametogenesis averaged 17.34 ± 0.53 (SE) mm in October and reached 22.00 ± 0.57 mm by February. In November, mussels from a second crab pot float were separated into two size classes (10–20 mm: 16.1 ± 0.3 mm; and 20–30 mm: 23.3 ± 0.2 mm). By December, the 10–20 mm size class reached 18.4 ± 0.3 mm, and the 20–30 mm size class reached 25.6 ± 0.2 mm. Growth was subsequently observed to cease for both groups (10–20 mm: 18.7 ± 0.3 mm by February; 20–30 mm: 25.8 ± 0.2 mm by February). While low mortality rates were recorded from October to February (11% and 6% for the 10–20 mm and 20–30 mm size classes, respectively) all mussels were dead by March.

Monthly averages of surface temperature and salinity readings were taken for the Skidaway River and are presented in Figure 2. Mean monthly water temperatures fluctuated from a high of 25.8°C in September 1999 to a low of 11.4°C in February, and then increased to 18.3°C in March 2000. The mean monthly salinity values remained high during the course of the study ranging from 26.3 ppt in October 1999 to 30.1 ppt in January 2000.

The paper mussel is dioecious. Of the 157 mussels that could be sexed, 128 were females and 29 were males. Females dominated in each monthly sample. The sex ratio (4.41 females to 1.00 male) was significantly different from parity (chi-square = 62.42). No hermaphrodites were observed.

Mussels were sexually mature prior to their arrival at the Shellfish Research and Aquaculture Laboratory in October 1999. Spawning mussels dominated in each month except February where 83% of individuals were spent (Figure 3). Ripe individuals were found in October (24.5%) but decreased in November (0%), December (4.2%), and January (14.3%).

DISCUSSION

Amygdalum papyrium appears to be an opportunistic and semelparous species. This study represents its first reported occurrence as a fouling organism on crab pot floats, dock floats, and dock pilings. Nest-building was not observed, the mussels were attached by the more normal style of mytilid byssus attachment. Mussels recruited in large numbers in the Satilla River in the summer months of 1999 grew rapidly, and were sexually mature by October. Prior to the initiation of the present study in October, most mussels were spawning, and indeed spawning individuals continued to dominate the reproductive stages until February 2000, when most mussels appeared spent. In Georgia, the mussel was observed to grow rapidly, had a prolonged spawning period, and then died. Mortality of the population occurred in March after the period of the lowest water temperature.

In October 1999 when mussels were first collected, they ranged in size from 4.4 mm to 28.9 mm. Mussels from the bottom of the crab pot float were larger than the mussels from the sides near the surface interface. The size difference may have resulted from more feeding opportunities on the underside of the float. The largest mussel recorded in the present study was 39.5 mm. Previously, Allen (1955) reported a maximum size for the Chesapeake Bay of 18.9 mm, however, he described the maximum *A. papyrium* size from the United States National Museum collection as 31.3 mm in shell length. It appears that mussels in March 2000 (25.8 mm ± 0.2) were at or approaching their maximum size when mass mortality of the cohort occurred.

Like most marine bivalve species, *A. papyrium* is

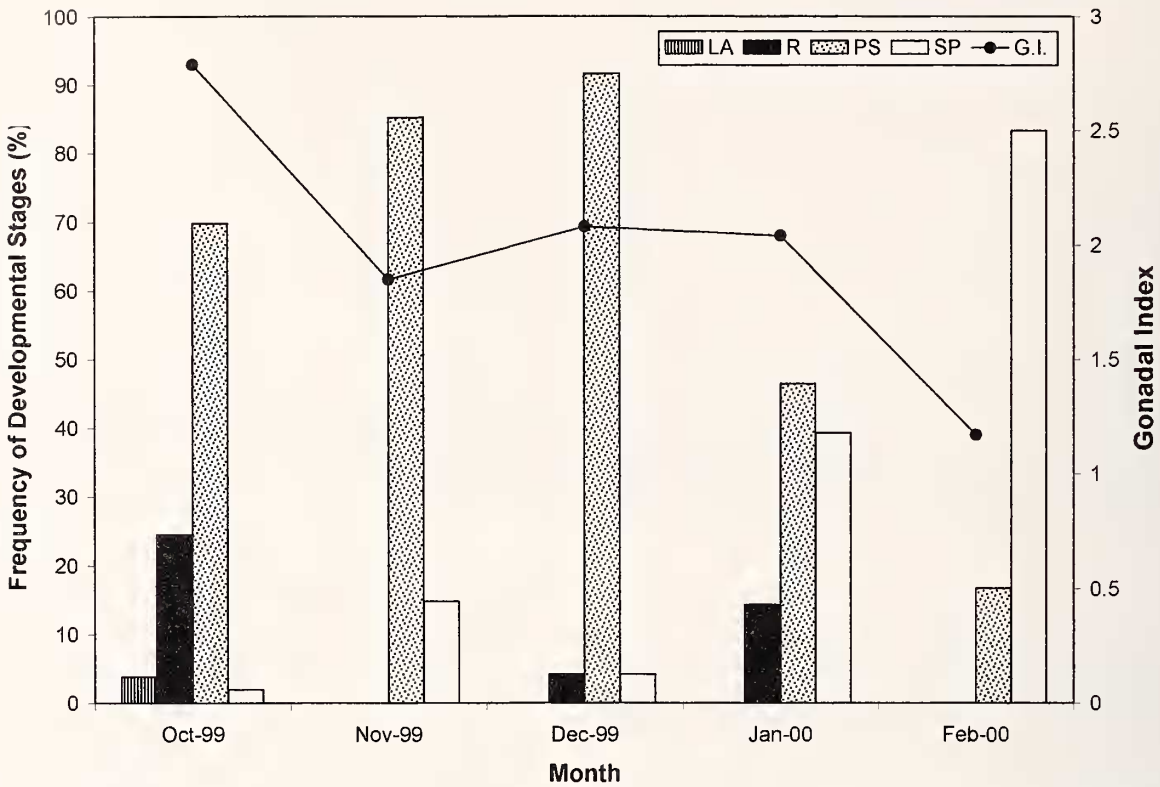

Figure 3. The relative frequency (percentage) of each gonadal developmental phase (LA = late active, R = ripe, PS = partially spawned, SP = spent) for *Amygdalum papyrium* from October 1999 to February 2000. Monthly gonadal index (G.I.) values were determined by averaging the number of specimens assigned to each category score (LA = 4, R = 5, PS = 2, SP = 1).

dioecious. In the present study, females dominated the population (4.41 females : 1.00 male). Oliver (2001) stated that sexes are separate in *Amygdalum anoxicolum* (Oliver, 2001) from the Arabian Sea, but gave no sexual ratio.

The massive occurrence of the mussel within traditionally brackish areas of the Satilla River led to concerns by coastal residents of degrading water quality in the river. It is our belief that the Atlantic papermussel is an opportunistic species that expanded its distribution into these areas as a result of the prolonged local drought conditions. The summer of 1999 was the second year of drought in the state and, as a result, full oceanic saline conditions (35 ppt) were recorded in areas of the Satilla River that are normally brackish to freshwater (unpublished data of the Marine Extension Service Satilla River Water Quality Monitoring Program). Castagna & Chanley (1973) reported a salinity tolerance range from <10 ppt to 45 ppt for *A. papyrium* in Virginia.

The senior author also collected small numbers of *A. papyrium* in August 1992 from the Satilla Clam Farm nursery plots located in Jointer Creek (adjacent to the mouth of the Satilla River) and in November 1986 from grow-out cages in the Crooked River located just south of St. Andrews Sound. The mussel has also been collected from Skidaway Island from bay scallop, *Argopecten irradians concentricus* (Say, 1822), nets in June 1986. *Amygdalum papyrium,* a native yet uncommon species in Georgia, grows rapidly, matures sexually at an early size and age, has a higher proportion of females, a prolonged spawning period, and thus can function as an opportunistic species. The occurrence of the paper mussel within normally brackish areas of the Satilla River was probably a result of the drought conditions and the opportunistic nature of the species.

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LITERATURE CITED

Abbott, R. T. 1974. American Seashells. 2nd ed. Van Nostrand Reinhold Company: New York. 663 pp.

Allen, J. F. 1955. A note on *Amygdalum papyrium* (Conrad, 1846) in Maryland waters of Chesapeake Bay. The Nautilus 68:83–87.

Castagna, M. A. & P. Chanley. 1973. Salinity tolerance of some marine bivalves from inshore and estuarine environments in Virginia waters on the western mid-Atlantic coast. Malacologia 12:47–96.

Elliott, J. M. 1977. Some methods for the statistical analysis of

samples of benthic invertebrates. Freshwater Biological Association Scientific Publication 25.

Fuller, S. C. & R. A. Lutz. 1989. Shell morphology of larval and post-larval mytilids from the north-western Atlantic. Journal of the Marine Biological Association of the United Kingdom 69:181–218.

Howard, D. W. & C. S. Smith. 1983. Histological techniques for marine bivalve mollusks. NOAA Technical Memorandum NMFS-F/NEC-25. 97 pp.

Morton, B. 1977. The biology and functional morphology of *Modiolus metcalfei* (Bivalvia: Mytilacea) from the Singapore mangrove. Malacologia 16:501–517.

Oliver, P. G. 2001. Functional morphology and description of a new species of *Amygdalum* (Mytiloidea) from the oxygen minimum zone of the Arabian Sea. Journal of Molluscan Studies 67:225–241.

Spruck, C., R. L. Walker, M. Sweeney & D. Hurley. 1994. Gametogenic cycle in the non-native Atlantic surfclam, *Spisula solidissima* (Dillwyn, 1817), cultured in the coastal waters of Georgia. Gulf Research Reports 9:131–137.

Walker, R. L. & P. B. Heffernan. 1994. Temporal and spatial effects of intertidal exposure on the gametogenic cycle of the northern, *Mercenaria mercenaria* (Linnaeus, 1758), in coastal Georgia. Journal of Shellfish Research 13:479–486.